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FUMIGATION OF DRY BEANS AND COWPEAS ON THE PACKAGING LINE

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Visible insect infestation in retail packages of dry beans or cowpeas not only destroys the acceptability of the infested package to the consumer, but also of the others in the same display. Normally the method of preventing this mishap is to fumigate the stock shortly before packaging to destroy all stages of the insects. Visibly infested beans or cowpeas are normally culled out prior to packaging. This method sometimes fails in that insects present in the warehouse or packaging plant deposit eggs on the fumigated stocks before they can be packaged.

Studies were begun in 1951 to develop a method of fumigating each individual retail package of beans or cowpeas on the packaging line, by adding a measured amount of fumigant to the filled package just prior to sealing. By this procedure it was anticipated that any insect eggs unintentionally included in the package would be killed and no infestation would develop from an internal source. The results of these studies are reported herein.

The insects that will usually infest retail packages by developing from eggs laid on the warehouse stocks are the bean weevil, Acanthoscelides obtectus (Say), the cowpea weevil Callosobruchus maculatus (F.), the Indian-meal moth Plodia interpunctella (Hbn.), the almond moth Ephestia cautella (Wlkr), the tobacco moth E. elutella (Hbn.), and related species. The two weevils are found in the warmer parts of the country and are particularly bothersome in California. The moths occur in all areas.

1/ This laboratory is one of the field stations of the Marketing Research Division, Biological Sciences Branch, Stored-Product Insects Section.

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EQUIPMENT AND MATERIALS

Two types of packages in common use were used in the studies, one of cellophane, and the other the conventional 1-pound cardboard carton with a 1½- x 2-inch cellophane window. The cellophane packages included 450-gage single and 300 duplex of both MST (moisture proof, heat sealing, and transparent) and PT (plain and transparent) types, sealed by the crimp, flat, and tape methods. The crimp seal was made by clamping the lips of the package between the corrugating jaws of an electrically-heated iron long enough to fuse the layers of cellophane. In the flat seal the edges were automatically folded and pressed against the contents of the package with a hot iron. The tape seal was used only with PT-type cellophane, and was done by hand with cellophane tape. The cartons were sealed by gluing down the full overlap ends in the usual manner.

The fumigants were measured by an automatic dispenser (Fig. 1). This dispenser consisted of a noncorroding stainless steel supply tank, a solenoid valve with a flow control adjustment, a timer which regulated the length of time the solenoid was open, and a microswitch. A voltage regulator was used to prevent fluctuations in the line current. The flow rate was adjusted by the control on the solenoid to the approximate amount, and the final adjustment was made by varying the dial setting on the timer. Amounts from 0.02 to 4 milliliters could be dispensed singly by these adjustments. The dispenser was calibrated by discharging 5 or 10 consecutive shots into a small graduated cylinder and adjusting until the average amount measured the desired discharge.

Thirteen fumigants were tested. The mixtures were combined on a volume/volume basis.

(1) Acrylonitrile - carbon tetrachloride (50-50)
(2) Acrylonitrile - carbon tetrachloride (10-90)
(3) Ethylene dibromide - carbon tetrachloride (5-95)
(4) Ethylene dibromide - carbon tetrachloride (15-85)
(5) Ethylene dibromide - tetrachloroethylene (5-95)
(6) Ethylene dibromide - tetrachloroethylene (15-85)
(7) Methyl bromide - carbon tetrachloride (10-90)
(8) Ethyl formate
(9) Ethyl formate - tetrachloroethylene (75-25)
(10) Propylene oxide

(11) Proprietary formula A, containing ethylene dibromide, ethyl acetate, propylene oxide, methyl formate, methylene chloride, chloroform, isopropyl alcohol 2/
(12) Carbon tetrachloride
(13) Tetrachloroethylene

Because of the intention of the Department of Industrial Relations of the State of California to lower the permissible concentration of carbon tetrachloride in working areas from 50 to 25 parts per million (p.p.m.) in air, tetrachloroethylene was included in some mixtures in place of carbon tetrachloride because its maximum allowable concentration is 100 p.p.m.

Egg, larvae, and pupae of the bean and cowpea weevils were used in all tests to evaluate the effectiveness of the various fumigants, because they are more resistant to fumigants than is the Indian-meal moth. The larval and pupal stages were in beans or cowpeas as they naturally developed. The eggs were also present in their normal manner, those of the bean weevil loose among the seeds, those of the cowpea weevil cemented to the surface of the seeds.

PROCEDURE

The effective dosage of each fumigant mixture was first determined for cellophane bags and cardboard cartons in laboratory tests, then for cellophane packages under packaging-line conditions. There was no opportunity to test cardboard cartons under packaging-line conditions.

Infested material in a perforated pill box was placed in the bottom of each test package, which was then filled with sound beans. The fumigant was applied and the package sealed. At the end of 24 hours the infested material was removed from the test package and held for an additional 30 days in an incubator. The effectiveness was determined by observing whether or not adults emerged from the material during this period.

In the laboratory tests the dosage was applied to the individual test packages by the automatic dispenser. In practical packaging-line tests the dispenser was placed just ahead of the sealing device and test packages were sent through the line for treatment and sealing, and then removed for observation.

2/ A proprietary fumigant mixture widely used in the California dried fruit industry.

Pilot tests were made in cooperation with two commercial packagers, to see if any adverse customer reaction resulted. Five thousand bags of pinto beans were distributed in Los Angeles in these tests, 4,600 bags of lima beans in Nebraska, Ohio, and West Virginia, and 5,100 bags of lima beans in Philadelphia.

Samples of fumigated blackeye cowpeas were submitted for taste tests to Dr. Elly Hinreiner of the Department of Food Technology, University of California, at Davis. These were fumigated with ethylene dibromide - carbon tetrachloride 5-95 and 15-85, and methyl bromide - carbon tetrachloride 10-90. In these tests the cowpeas were washed, sorted, and soaked for 4 hours. The water was drained, measured, and replaced with additional water over the cowpeas to make 1,250 milliliters. The cowpeas were cooked for 1 hour after adding 1 teaspoonful of salt, and served warm to the taste panel that had been trained to detect the chemicals. The panel conducted three taste tests on different days for each treated sample.

Observations were also made during the pilot tests to determine the concentration of fumigant found in the packaging room.

RESULTS

The results of various application rates of each of the fumigants are given in table 1, for each type of package. The minimum effective rate, where established, is shown in table 2.

These minimum effective dosage rates were found to be insufficient under practical conditions where the automatic packaging machine made a flat seal. A schedule of dosage rates for the fumigants found effective under commercial use conditions is given in table 3. A calculated cost per ton of commodity with each of the fumigants is also given in table 3.

No adverse customer reaction resulted in the pilot tests where 14,700 packages of fumigated beans were distributed through regular retail channels in five different areas.

The taste panel at the University of California, at Davis, reported "the data clearly indicate that the treatments resulted in no unusual flavor in the cowpeas, and that indeed there was no significant difference between the treated and untreated cowpeas."

The concentration of fumes in the packaging room varied as follows when the doors and windows were open and when they were closed: With natural ventilation samples taken in the breathing zone of an

operator ranged between 2 and 4 p.p.m. when using the ethylene dibromide - carbon tetrachloride (15-85) mixture. With no ventilation concentrations rose to 25 p.p.m.

SUMMARY

Studies were begun in 1951 to develop a method of fumigating individual retail packages of beans or cowpeas on the packaging line by adding a small measured amount of fumigant to the filled package just prior to sealing. This was done to prevent infestation developing from insect eggs accidentally included in the package. An automatic dispenser was used to apply the measured dosage to each package. Thirteen fumigants were tested in laboratory tests on 1-pound cellophane bags and cardboard cartons. Six of the fumigants were tested on a packaging line under commercial conditions, and cellophane bags were used. Effective dosage of these selected fumigants ranged from 0.2 to 0.3 ml. per bag under packaging-line conditions at costs for the fumigant ranging from 23 to 49 cents per ton of commodity. Taste tests demonstrated no change in the flavor of cowpeas, and pilot tests with industry members revealed no adverse customer reaction.

Table 1.--Prevention of insect development in cellophane bags and cardboard cartons of beans and cowpeas resulting from the addition of fumigants at the time of packaging

Fumigant	Application per 1-pound package	Cellophane bag tests		Carton tests	
		Development prevented	Development not prevented	Development prevented	Development not prevented
	Milliliters	Number	Number	Number	Number
Acrylonitrile - carbon tetrachloride (50-50)	0.1	2	0	-	-
	.2	18	0	-	-
	.25	11	0	1	0
	1.0	3	0	-	-
Acrylonitrile - carbon tetrachloride (10-90)	.1	2	1	0	1
	.2	20	4	0	2
Ethylene dibromide - carbon tetrachloride (5-95)	.02	0	4	-	-
	.03	12	2	-	-
	.05	12	8	-	-
	.075	9	1	-	-
	.1	60	0	0	1
	.125	25	0	0	1
	.15	10	0	-	-
	.2	42	1	0	1
	.3	10	0	-	-
	.4	-	-	0	6
	.5	-	-	0	11
	.6	-	-	3	10
	.7	-	-	0	5
	.8	-	-	0	10
Ethylene dibromide - carbon tetrachloride (15-85)	.02	4	10	-	-
	.03	14	0	-	-
	.0375	10	0	-	-
	.04	5	0	-	-
	.05	77	0	-	-
	.075	20	0	-	-
	.1	49	3	0	1
	.2	44	0	1	0
	.3	13	0	-	-
	.4	-	-	1	5
	.5	-	-	7	4
	.6	-	-	8	3
	.7	-	-	2	3
	.8	-	-	10	0

Table 1.--Prevention of insect development in cellophane bags and cardboard cartons of beans and cowpeas resulting from the addition of fumigants at the time of packaging--Continued

Fumigant	Application per 1-pound package	Cellophane bag tests		Carton tests	
		Development prevented	Development not prevented	Development prevented	Development not prevented
	Milliliters	Number	Number	Number	Number
Ethylene dibromide - tetrachloroethylene (5-95)	0.03	2	8	-	-
	.05	8	2	-	-
	.1	10	0	-	-
Ethylene dibromide - tetrachloroethylene (15-85)	.03	9	1	-	-
	.05	10	0	-	-
Methyl bromide - carbon tetrachloride (10-90)	.02	0	5	-	-
	.0375	8	2	-	-
	.05	37	3	-	-
	.075	25	0	-	-
	.1	30	0	-	-
	.2	8	1	-	-
	.4	-	-	0	5
	.5	-	-	0	10
	.6	-	-	0	10
	.7	-	-	0	5
	.8	-	-	0	10
Ethyl formate	.1	1	3	0	2
	.15	0	28	-	-
	.2	36	48	0	1
	.25	11	14	-	-
	1.0	2	0	-	-
Ethyl formate - tetrachloroethylene (75-25)	.05	0	16	-	-
	.1	0	16	-	-
	.15	0	14	-	-
Propylene oxide	.02	1	3	-	-
	.03	0	4	-	-
	.1	2	2	-	-
	.15	23	5	-	-
	.2	83	5	-	-
	.25	23	1	-	-
	.3	26	2	-	-
	1.0	2	0	-	-

Table 1.--Prevention of insect development in cellophane bags and cardboard cartons of beans and cowpeas resulting from the addition of fumigants at the time of packaging--Continued

Fumigant	Application per 1-pound package	Cellophane bag tests		Carton tests	
		Development prevented	Development not prevented	Development prevented	Development not prevented
	Milliliters	Number	Number	Number	Number
Proprietary formula A	0.02	4	0	-	-
	.03	4	0	-	-
	.2	12	0	-	-
	.3	1	0	-	-
	.5	-	-	2	0
	.6	-	-	2	0
Carbon tetrachloride	.05	10	10	-	-
	.1	34	21	-	-
	.125	1	9	-	-
	.15	28	12	-	-
	.175	8	2	-	-
	.2	40	5	-	-
	.25	20	0	-	-
	.3	24	7	-	-
	.4	8	1	-	-
	.5	5	0	-	-
	.8	-	-	0	1
	1.0	-	-	0	1
	1.2	-	-	1	0
Tetrachloroethylene	.1	8	2	-	-
	.15	9	1	-	-
	.2	10	0	-	-

Table 2.--Minimum application rates of fumigants resulting in complete prevention of insect development in 1-pound cellophane bags and cardboard cartons. Summarized from table 1.

Fumigant	Rate for cellophane bags	Rate for cardboard cartons
	Milliliters	Milliliters
Acrylonitrile - carbon tetrachloride (50-50)	0.1[1/]	0.25
Ethylene dibromide - carbon tetrachloride (5-95)	.075[2/]	above .8
Ethylene dibromide - carbon tetrachloride (15-85)	.03[3/]	.8
Ethylene dibromide - tetrachloroethylene (5-95)	.1	-
Ethylene dibromide - tetrachloroethylene (15-85)	.05	-
Methyl bromide - carbon tetrachloride (10-90)	.75[4/]	above .8
Ethyl formate	1.0	-
Propylene oxide	1.0	-
Proprietary formula A	.02	.5
Carbon tetrachloride	.5	1.2
Tetrachloroethylene	.2	-

1/ Lowest dosage rate tested
2/ Two exceptions in 156 tests
3/ Three exceptions in 232 tests
4/ One exception in 63 tests

Table 3.--Application rates of some fumigants found effective under practical operating conditions where flat heat seal was used, in cellophane bags, and cost of fumigant per ton of commodity.

Fumigant	Rate per 1-pound bag	Cost per ton of commodity 1/
	Milliliters	Dollars
Ethylene dibromide - carbon tetrachloride (5-95)	0.3	0.27
Ethylene dibromide - carbon tetrachloride (15-85)	.2	.23
Ethylene dibromide - tetrachloroethylene (5-95)	.3	.49
Ethylene dibromide - tetrachloroethylene (15-85)	.2	.36
Methyl bromide - carbon tetrachloride (10-90)	.3	.38
Proprietary formula A	.2	.22

1/ Based on cost of ingredients as follows:
Carbon tetrachloride - $1.48 per gallon in drum lots
Tetrachloroethylene - .215 per pound in drum lots
Ethylene dibromide - .45 per pound in drum lots
Methyl bromide - .72 per pound in 50-pound lots
Proprietary formula A- .275 per pound in 50 gallon lots

Figure 1.--Automatic dispenser used in these tests to apply the fumigants to the test packages. The picture shows, from top to bottom, the fumigant supply tank, the timer, the solenoid valve with delivery tube, and, on table beside open package of beans, the microswitch.

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